NSF ITR Project:

Computational Tools for Modeling, Visualizing and Analyzing Historic and Archaeological Sites

www.cs.columbia.edu/~allen/ITR

Columbia Project Participants

Interdisciplinary project with overall goal of bringing new digital technologies and methods to Archaeology & Historic Preservation

- Peter Allen(PI), Computer Science
- James Conlon, Media Center for Art History
- Steven Feiner, Computer Science
- Lynn Meskell, Anthropology
- Stephen Murray, Art History and Archaeology
- Kenneth Ross, Computer Science
- Roelof Versteeg, Environmental Engineering

Project Goals

- Build accurate above-ground site models
- Image below-ground data and merge with above-ground models
- New database technology to catalogue and access a site
- Visualization systems that integrates above- and below-ground models, images, text, web-based resources to annotate the physical environment.
- Developing an educational interface that will permit remote access to the models

Project Highlights

NYC:

- Scanned and modeled Cathedral of St. John Divine, NYC
- Developed adaptive acquisition method for underground data
- Modeled archeology domain and implemented prototype archaeological database query system

France:

- Scanned and modeled Cathedral, Ste. Pierre, Beauvais

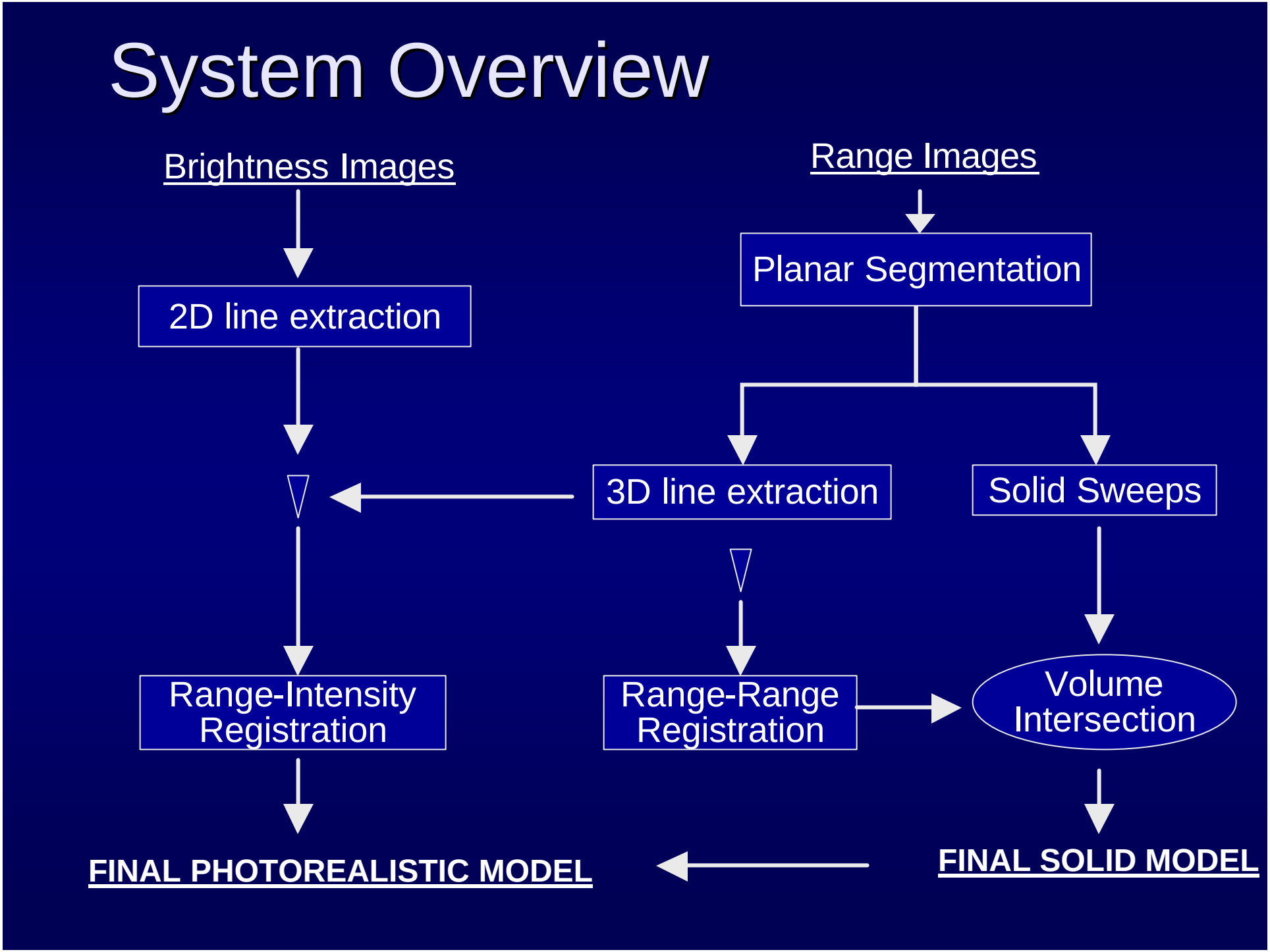
Egypt:

- Detailed topographic survey, including building footprints
- Photographic documentation and magnetic sensing conducted
- Produced online zoomable panoramas of site
- Online GIS system developed at site

3D Site Modeling:Technical Challenges

- Create Global and coherent geometry: handle full range of geometries
- Registration of multiple point sets
- Reducing data complexity
- Range and intensity image fusion
- Planning viewpoints for efficient and complete scanning

System Overview



The AVENUE Mobile Platform

A *UTONOMOUS*

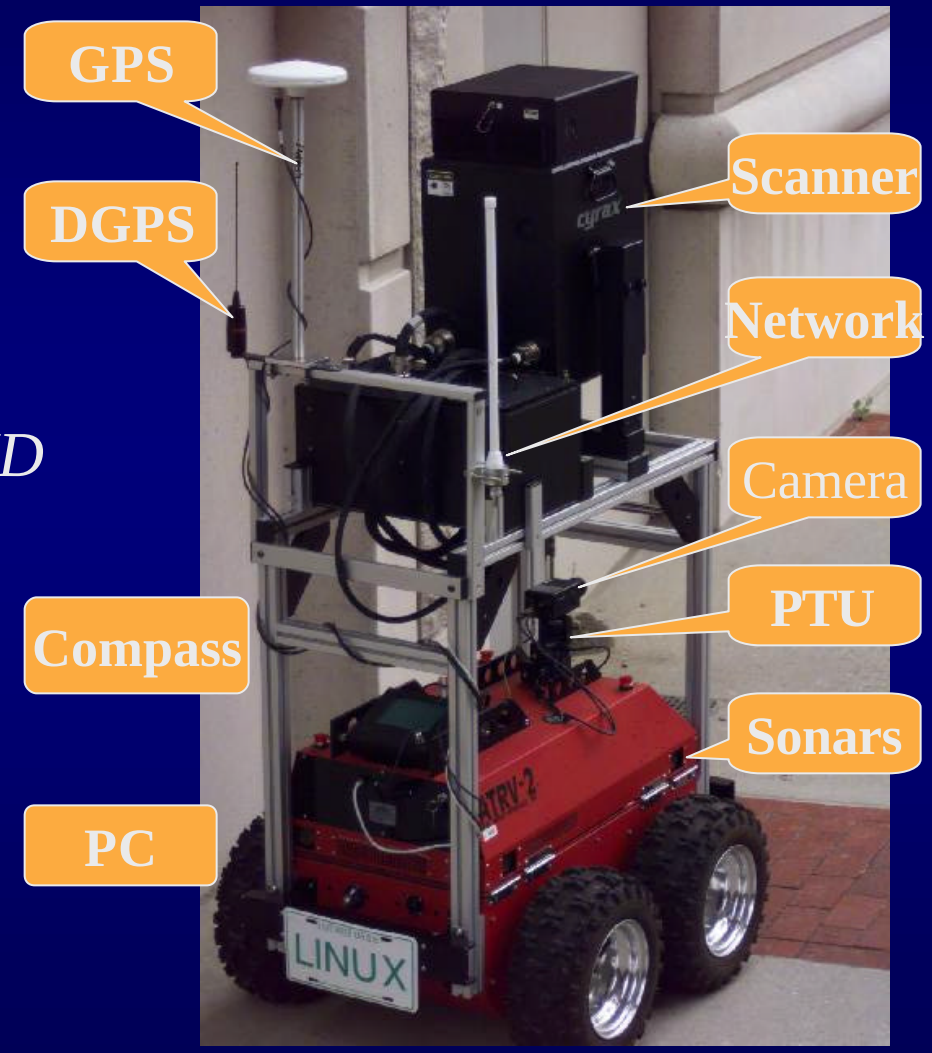
V *EHICLE FOR*

E *XPLORATION AND*

N *AVIGATION IN*

U *RBAN*

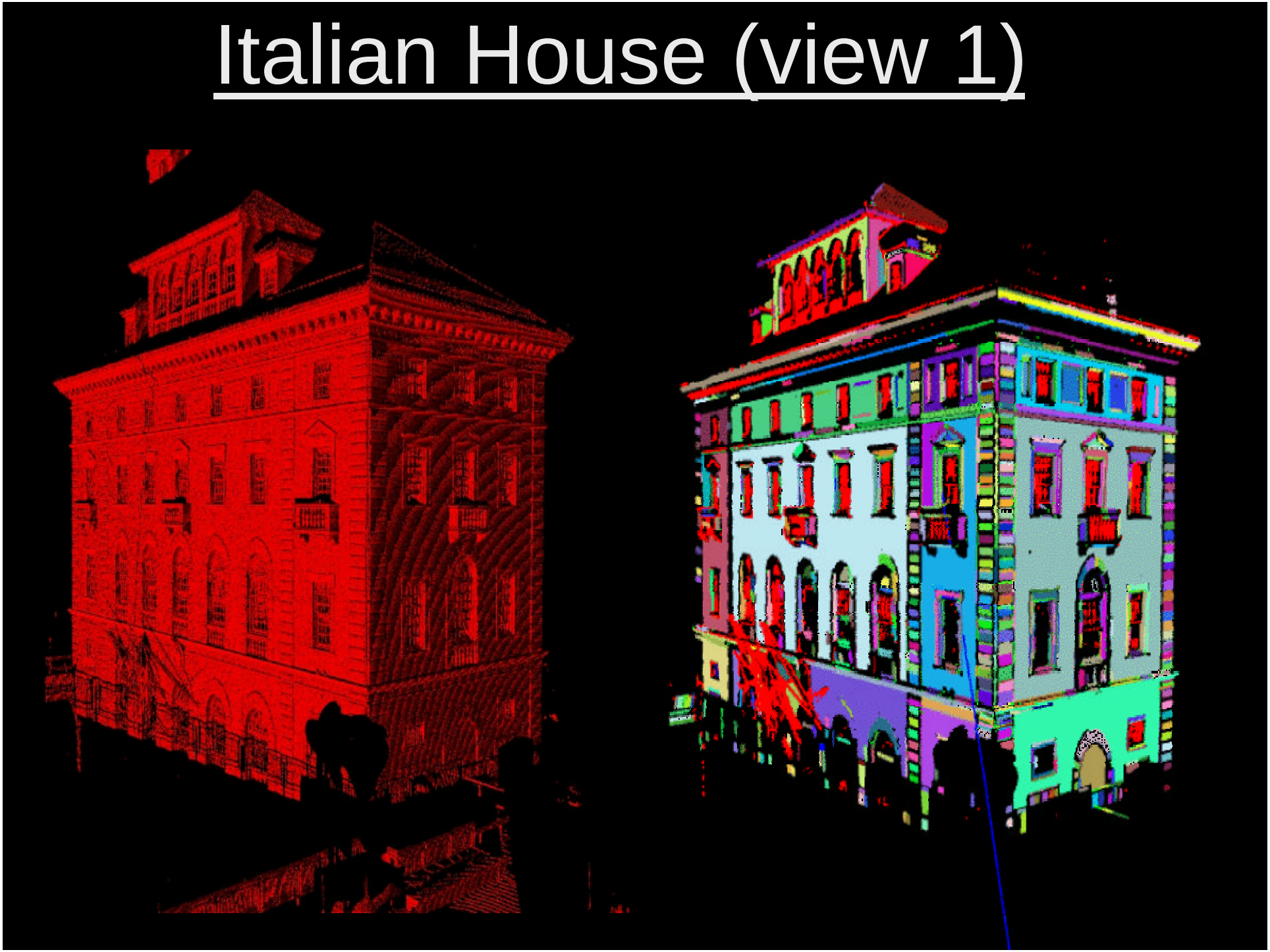
E *NVIRONMENTS*



Data Acquisition

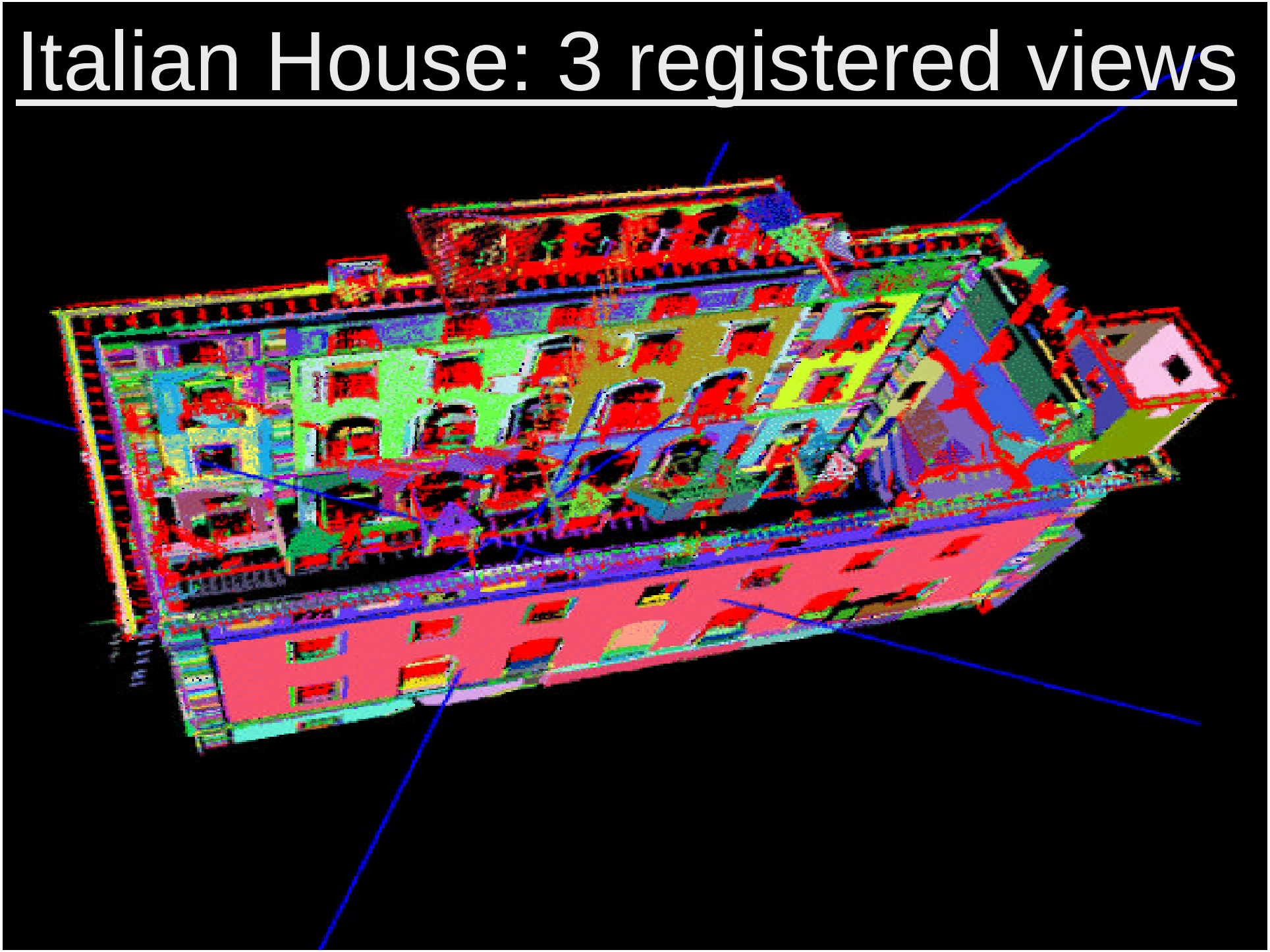
- Spot laser scanner
- Time of flight.
- Max Range: 100m.
- Scanning time: 15 minutes for 1000 x1000 points.
- Accuracy: 6mm.

Italian House (view 1)

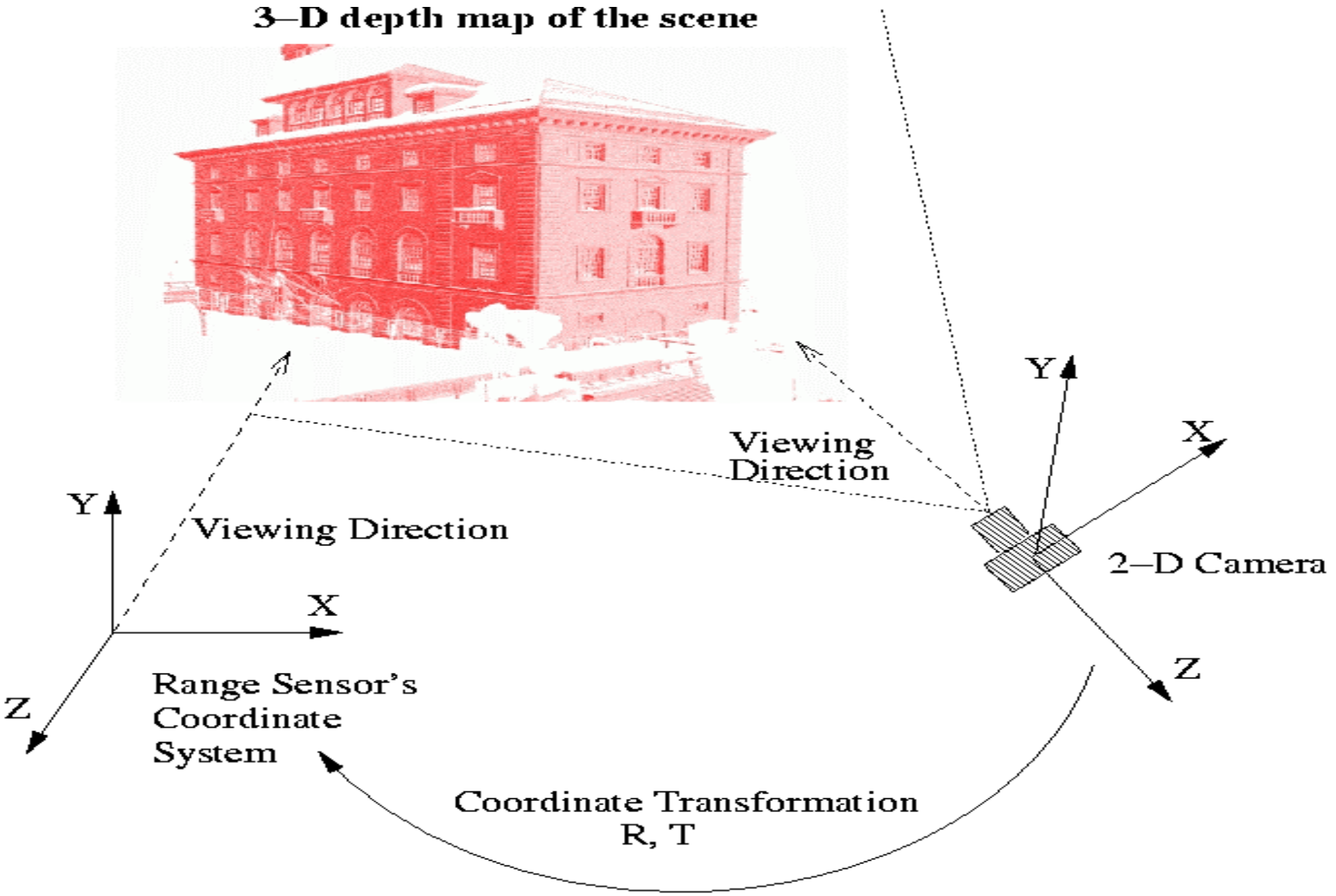


3D lines (Italian House)

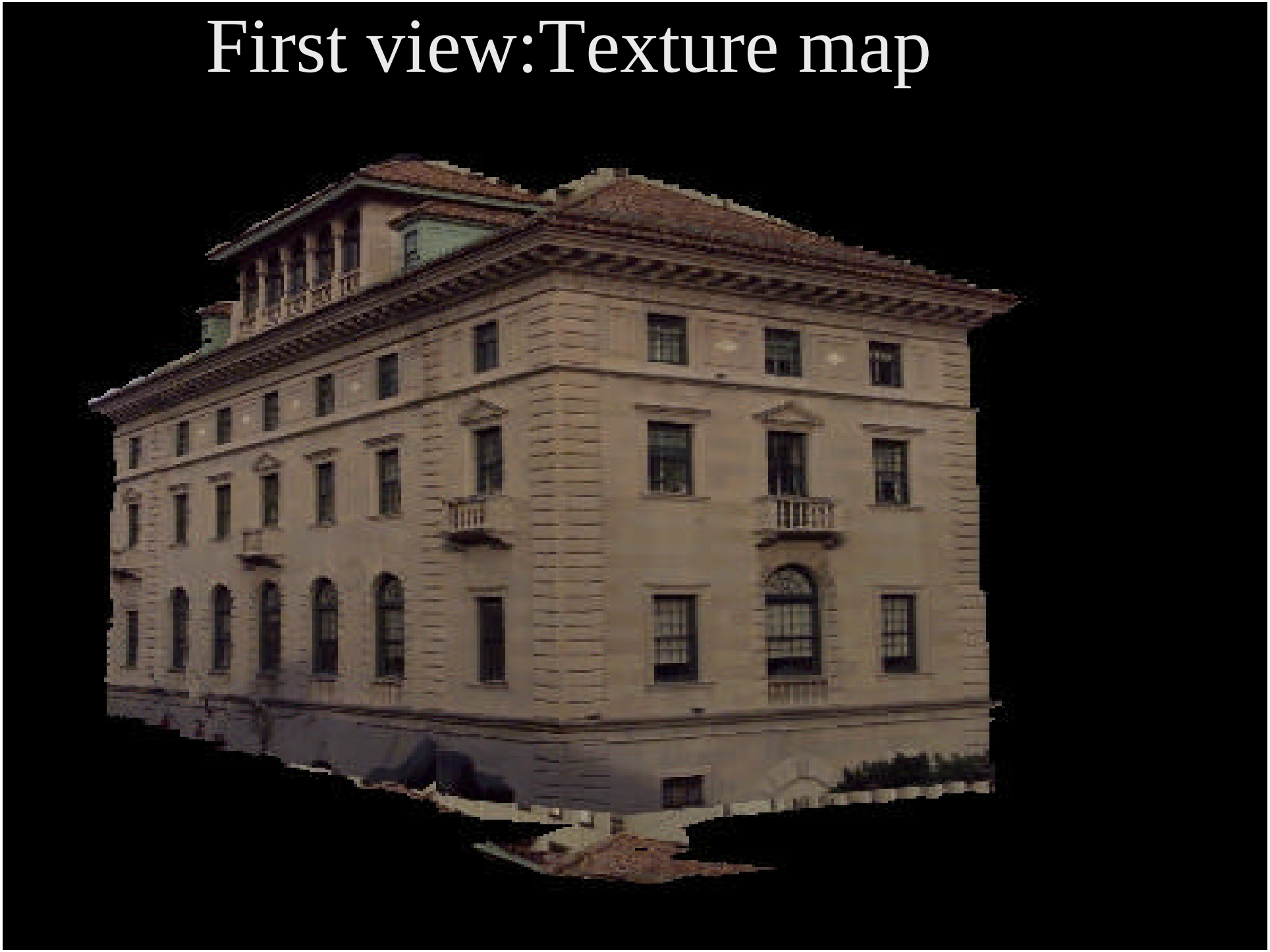
Italian House: 3 registered views



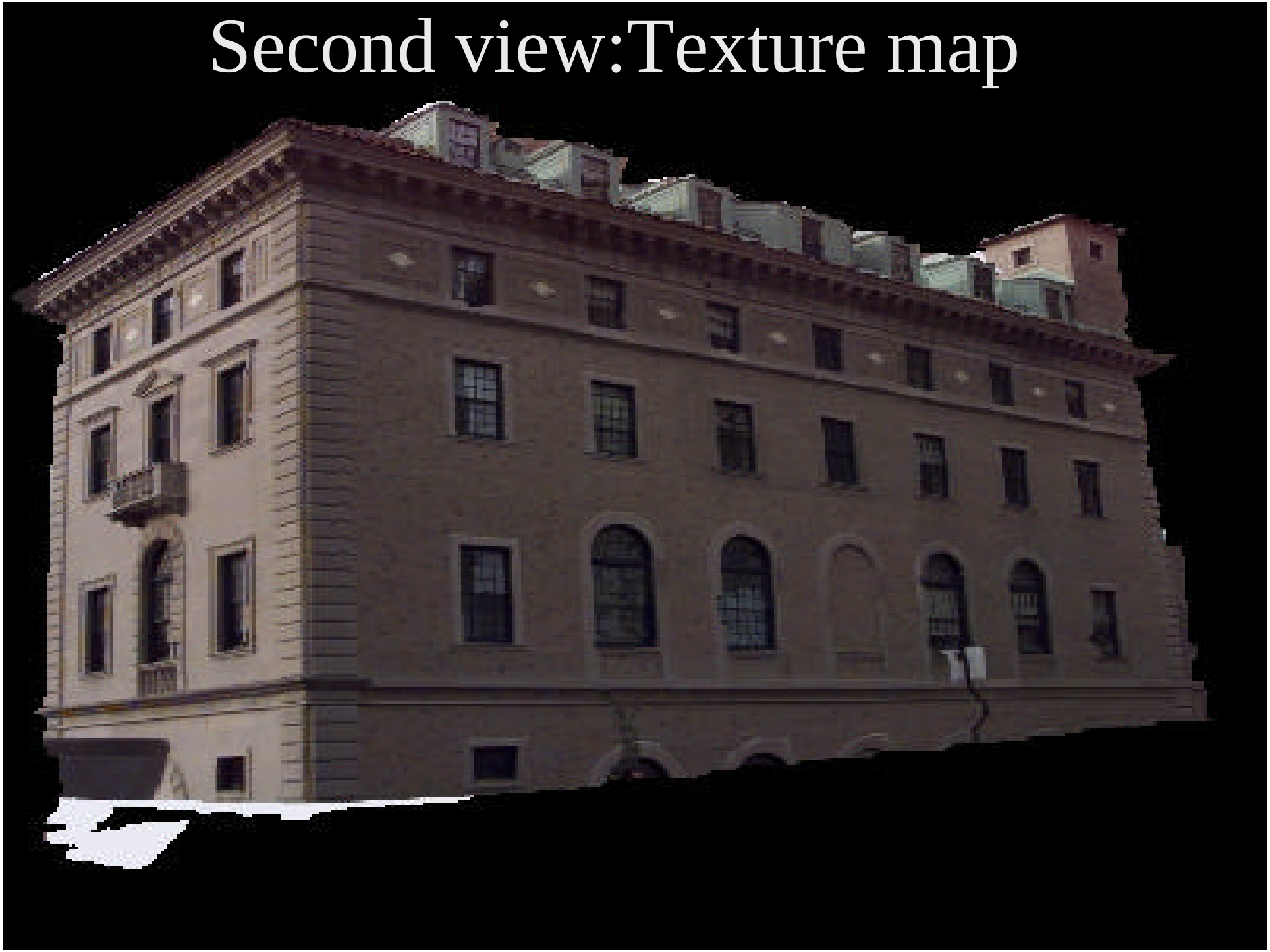
Range-Intensity Registration

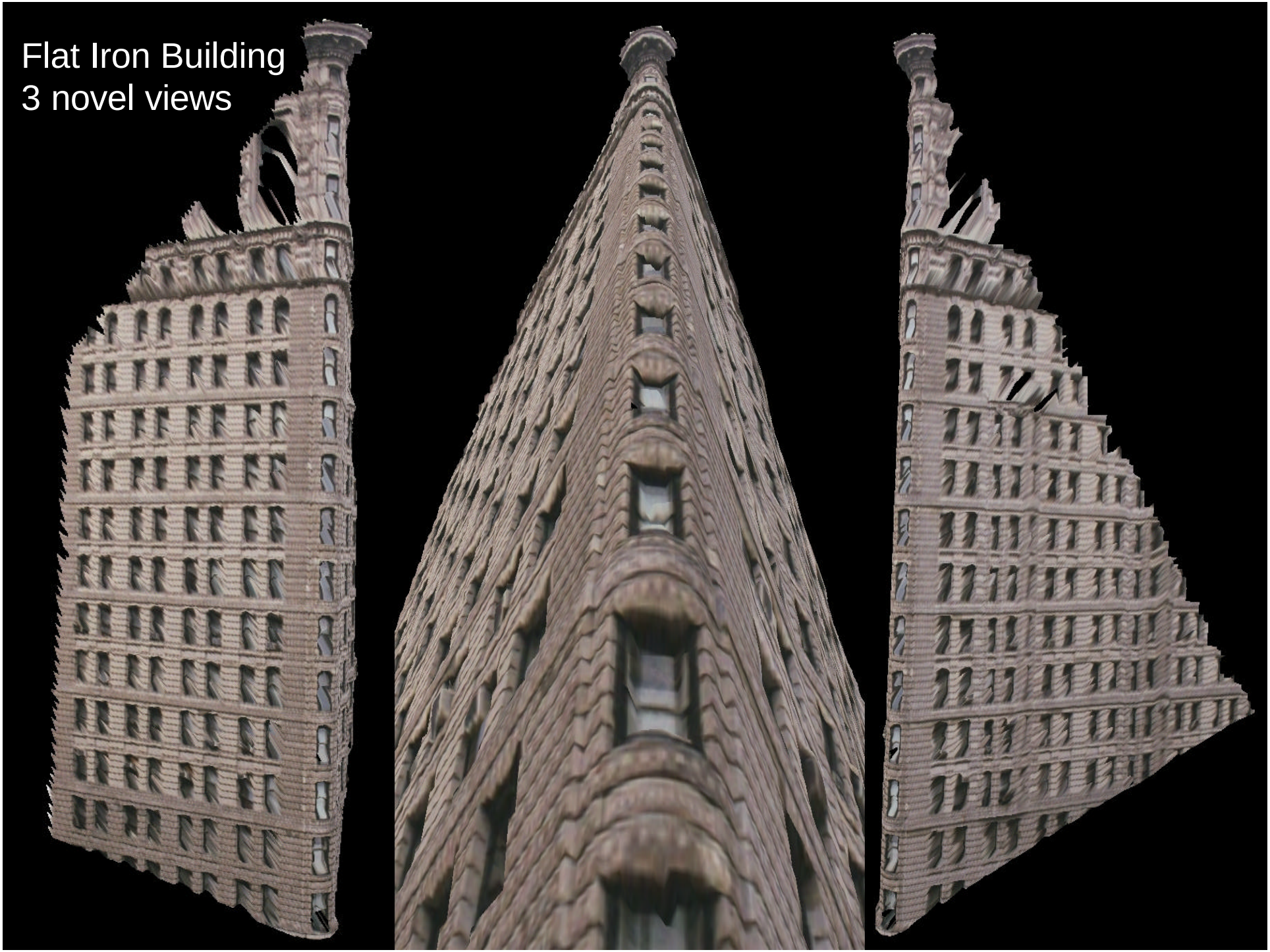


First view:Texture map



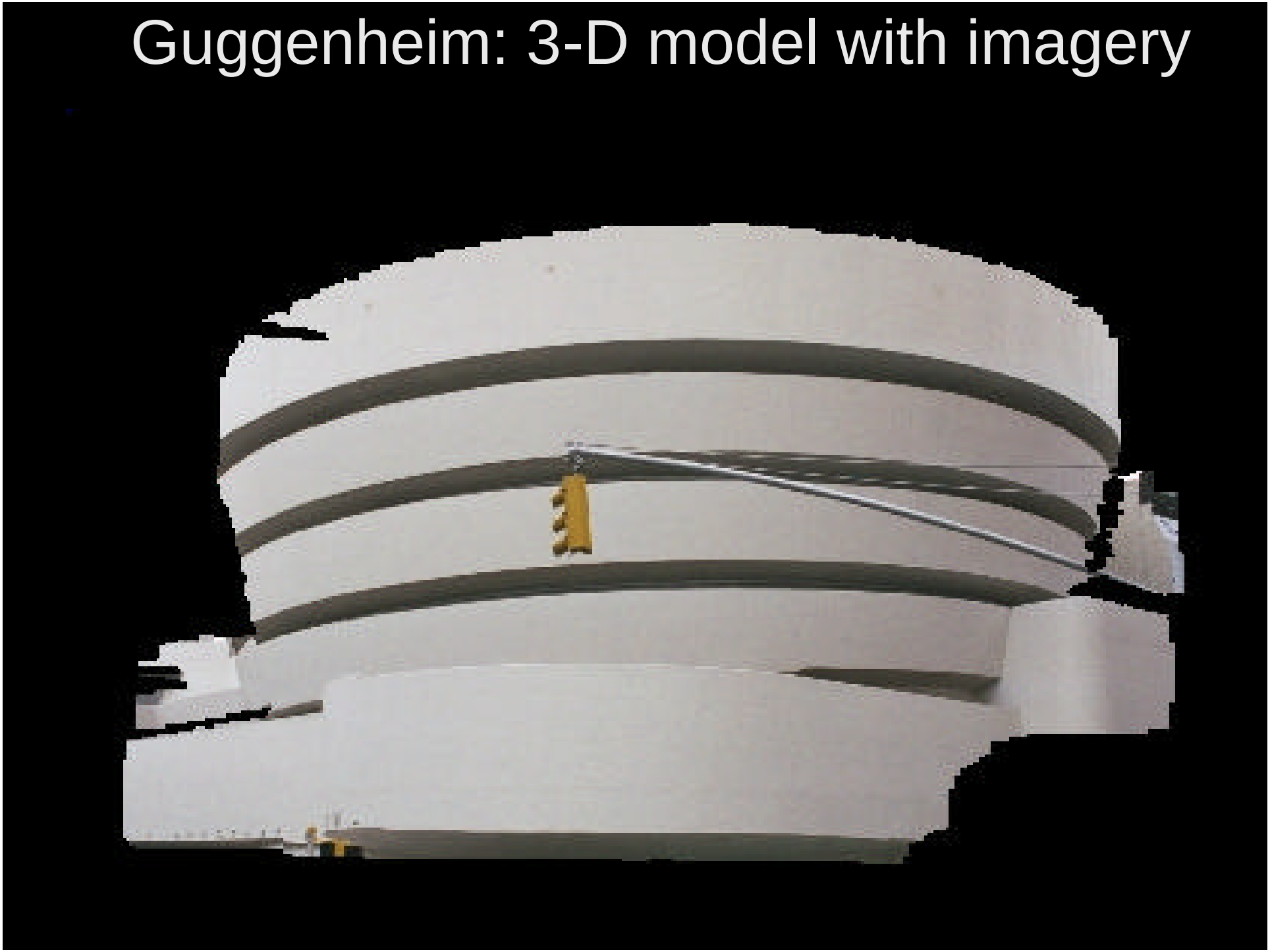
Second view:Texture map



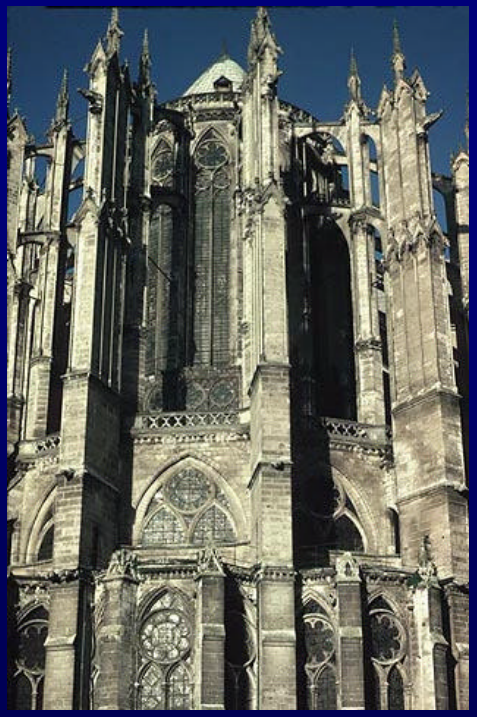

Flat Iron Building
3 novel views

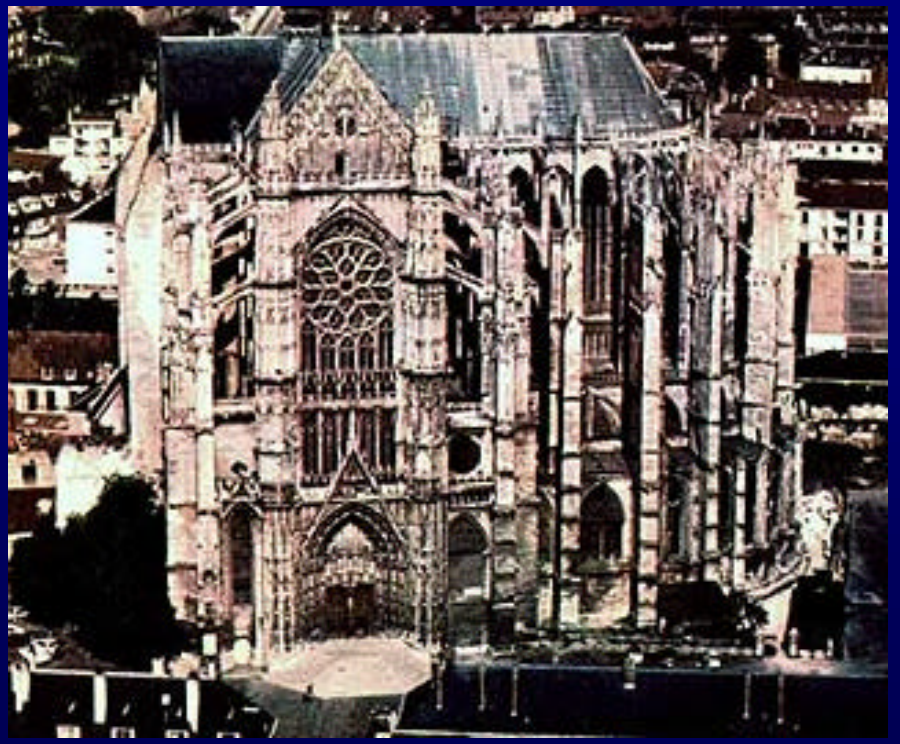
Guggenheim Museum, NYC

Guggenheim: 3-D model with imagery



Cathedral Ste. Pierre, Beauvais, France





Modeling the Cathedral

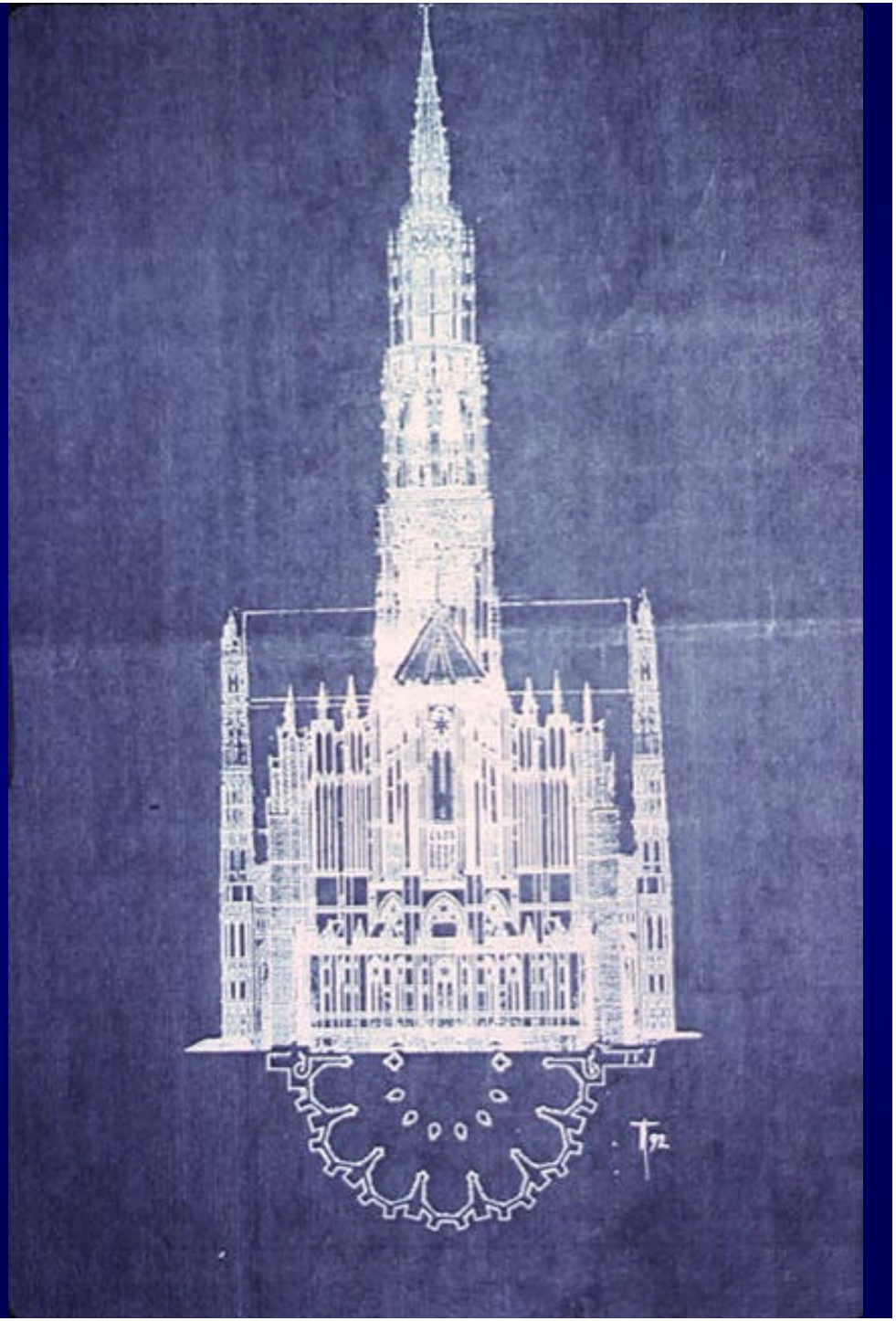
Goals:

- Create 3-D model to examine weaknesses in the building and proposed remedies
- Establish baseline for condition of Cathedral
- Visualize the building in previous contexts
- Basis for a new collaborative way of teaching about historic sites, in the classroom and on the Internet.
- Cathedral on the World Monuments Fund's Most Endangered List.

History: 1200 - 1600

- Commissioned in 1225 by Bishop Milon de Nanteuil
- Only the choir and transepts were completed - choir in 1272
- In 1284 part of the central vault collapsed
- Area where the nave and façade would be is still occupied by the previous church constructed just before 1000.
- Completed in 16th century, the transept was crowned by an ambitious central spire that allowed the cathedral to rival its counterpart in Rome.
- The tower collapsed on Ascension Day in 1573.

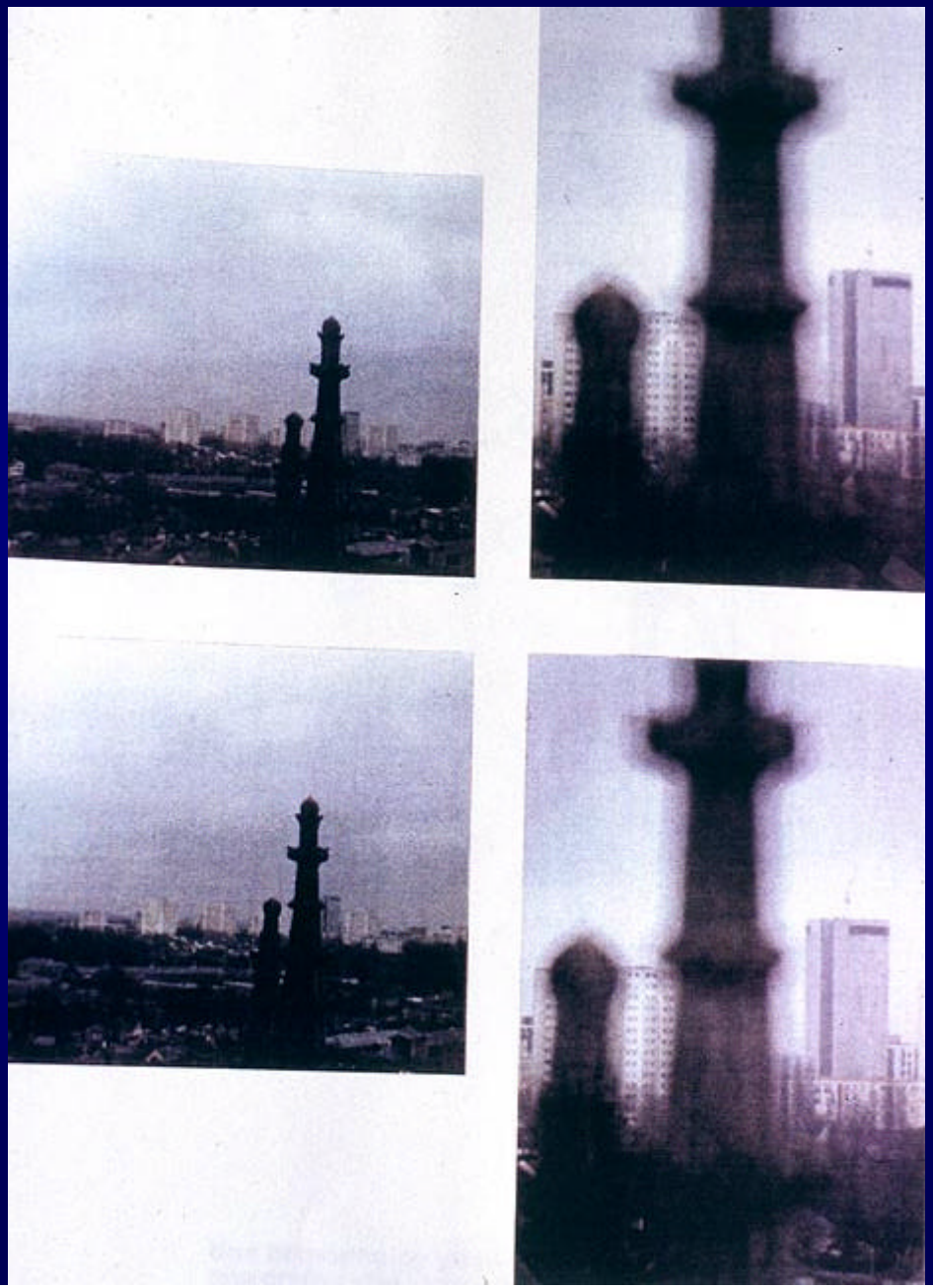
Rendition of original central spire



Problems with the Structure

- Wind Oscillation from English Channel winds
- Strange inner and outer aisle construction – can cause rotational moments in the structure
- Leaking Roof, foundation is settling
- Built in 3 campaigns over hundreds of years with differing attention to detail
- There continues to be a lack of consensus on how to conserve the essential visual and structural integrity of this Gothic wonder.

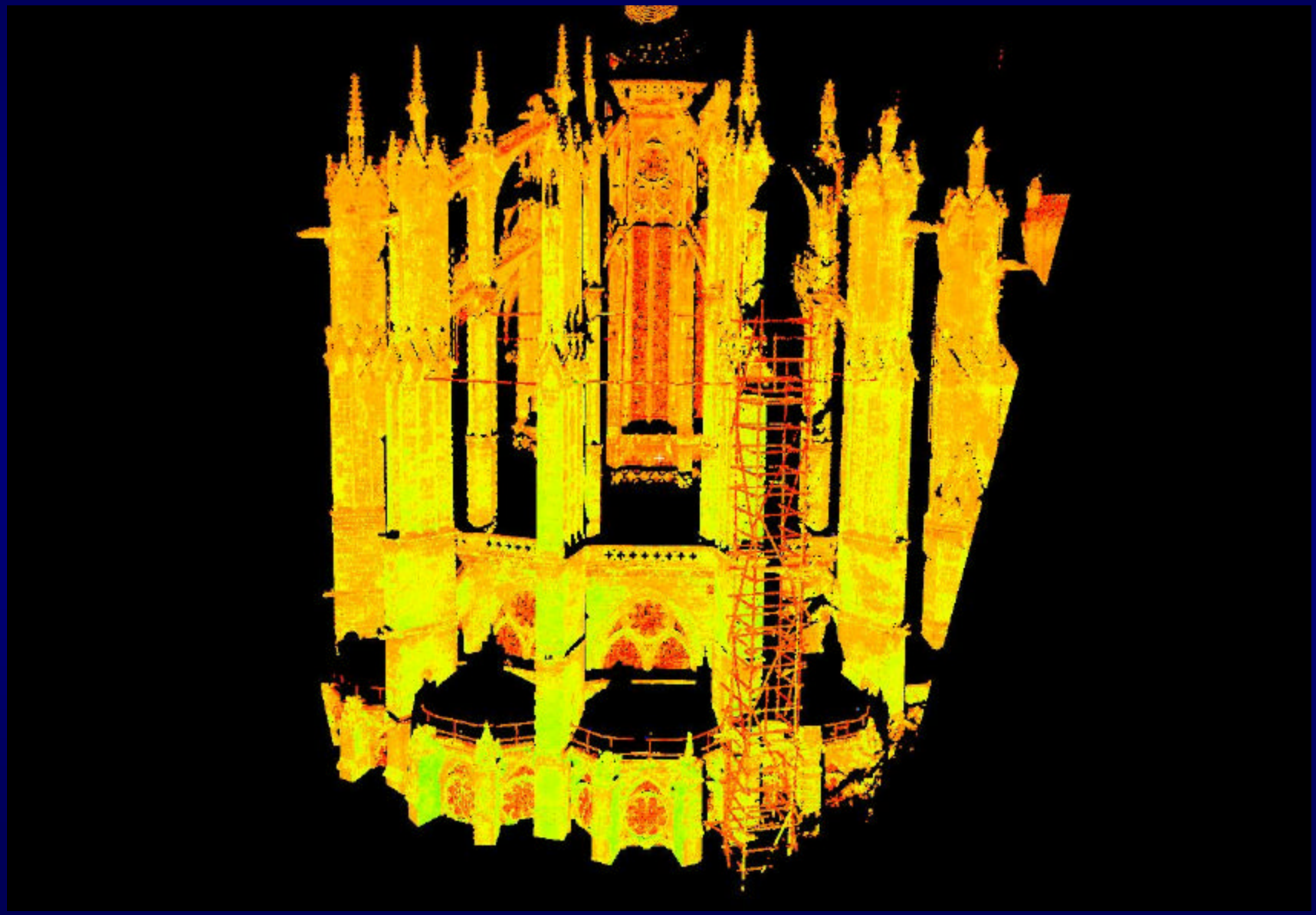
Time-Lapse Image - Spire Movement Due to Wind



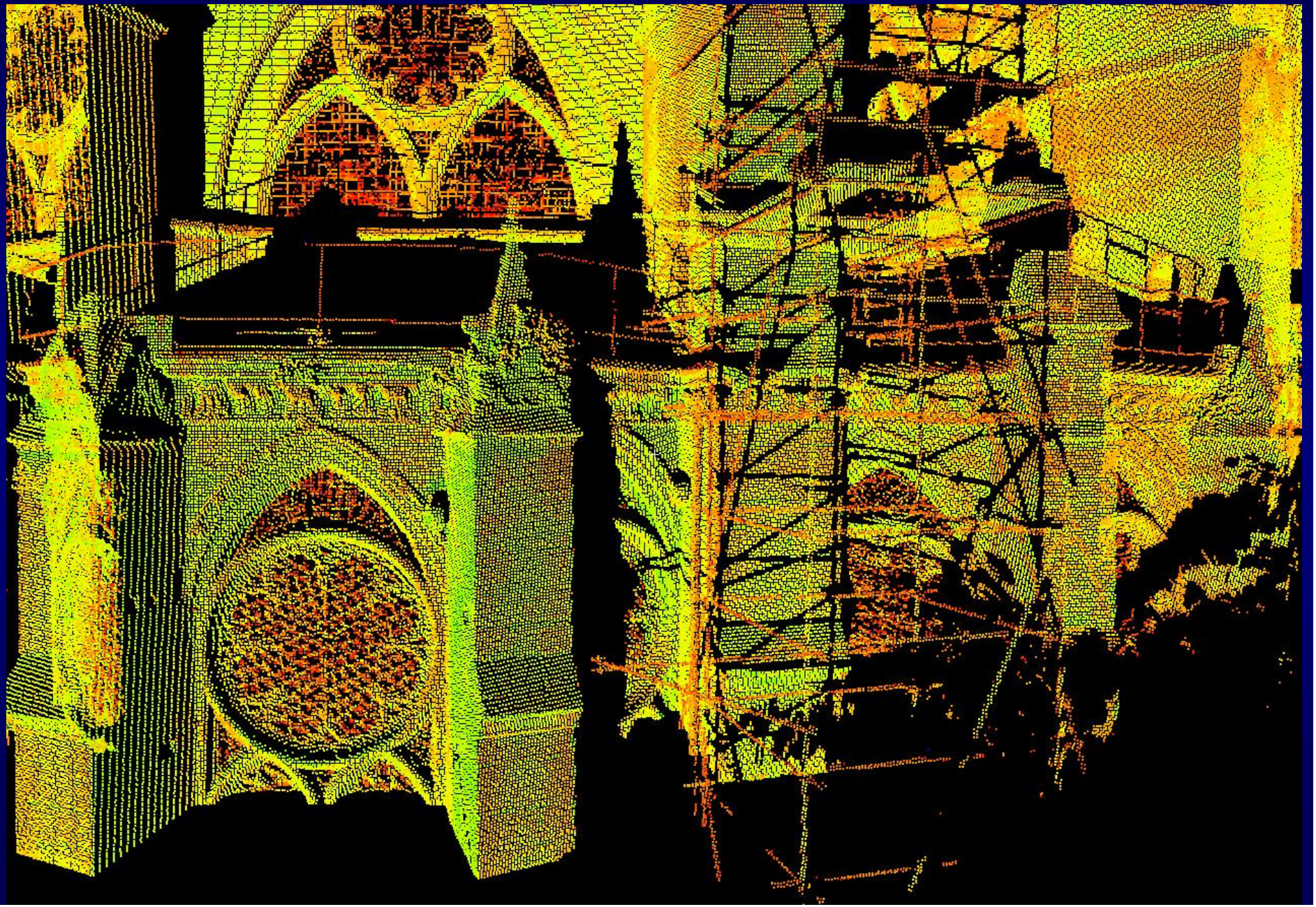
Beauvais Cathedral: Exterior Scanning Session

Beauvais Cathedral: Interior Scanning Session

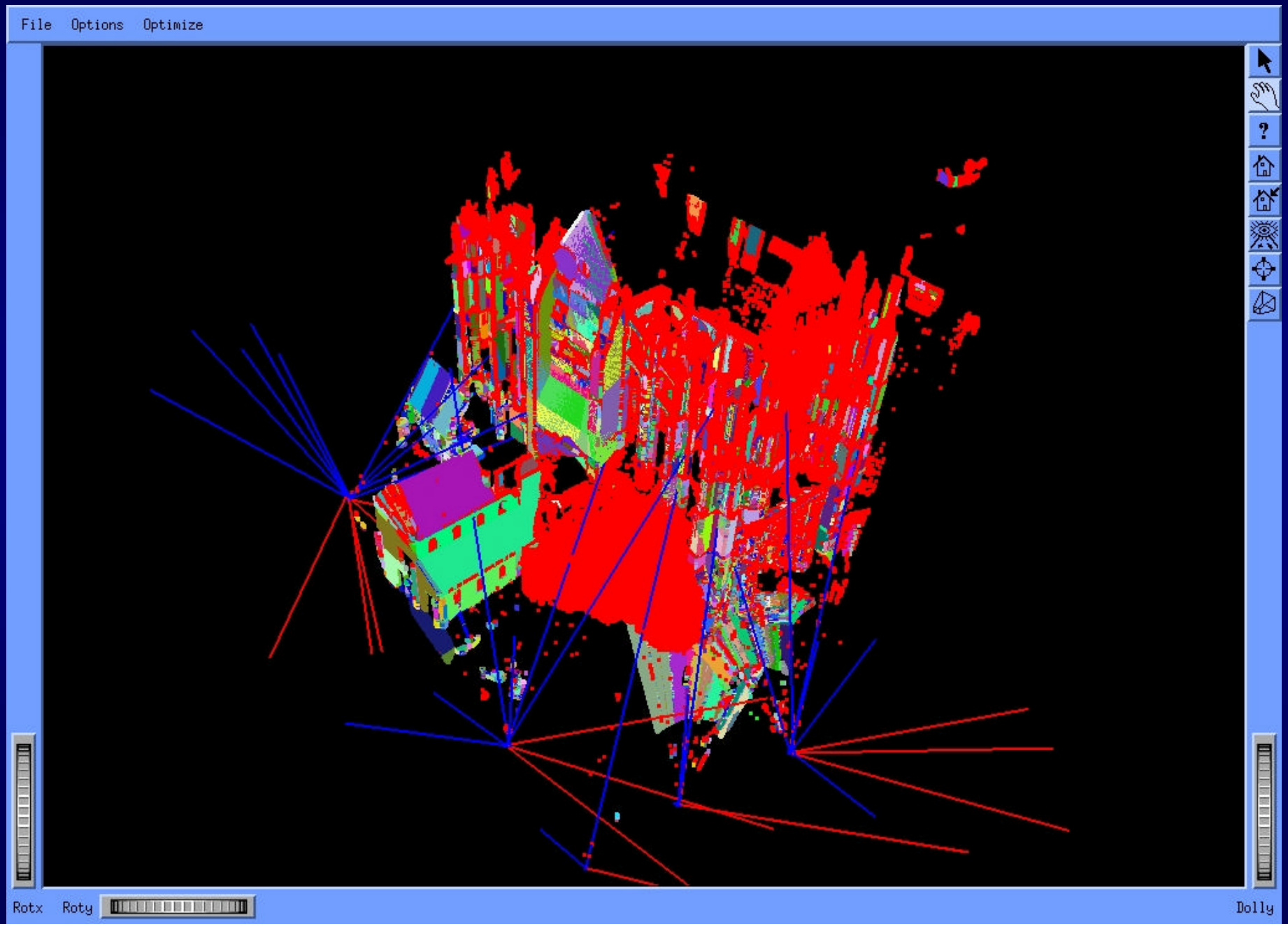
Exterior: Raw Range Scan



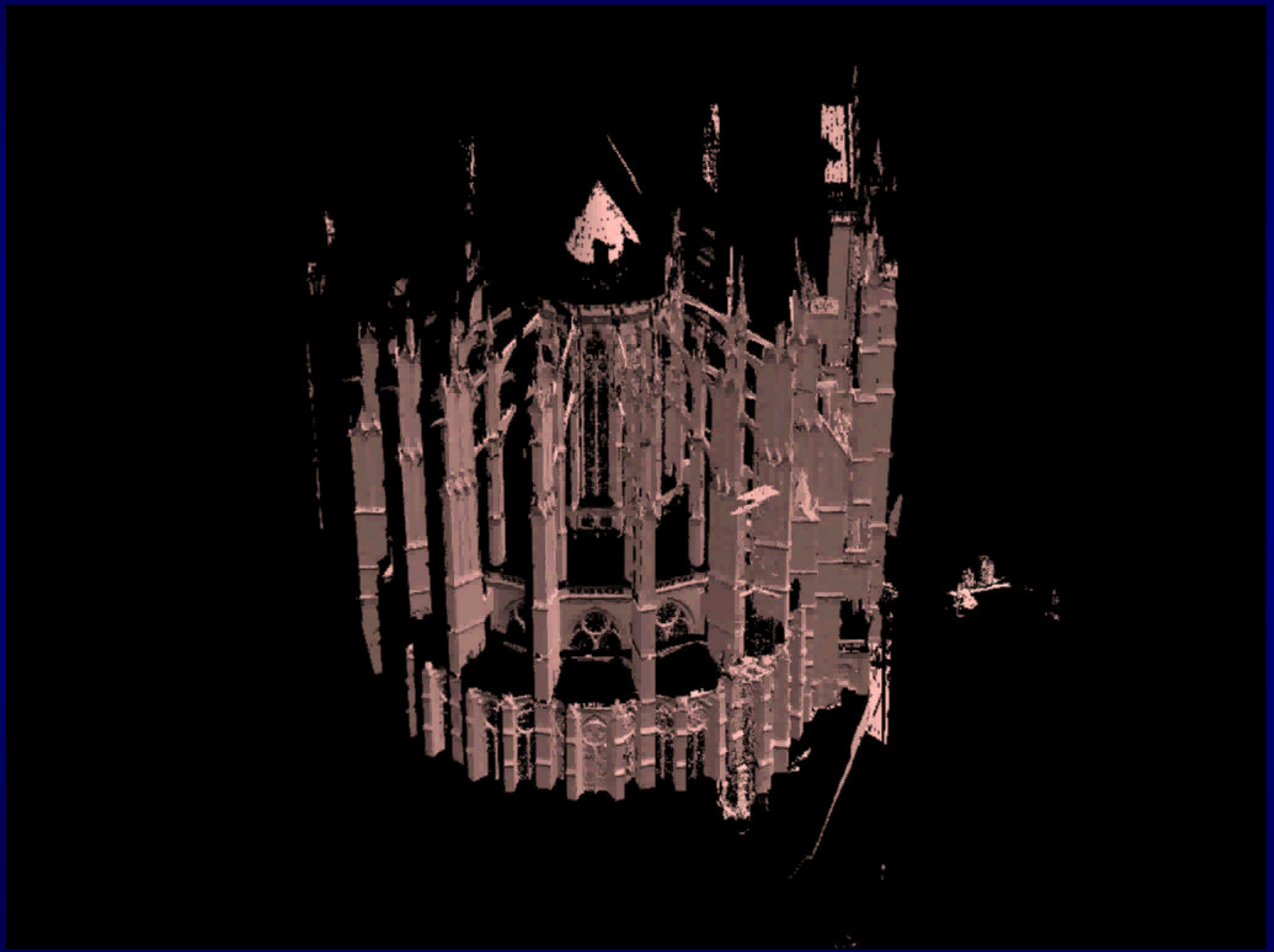
Beauvais: Scan Detail



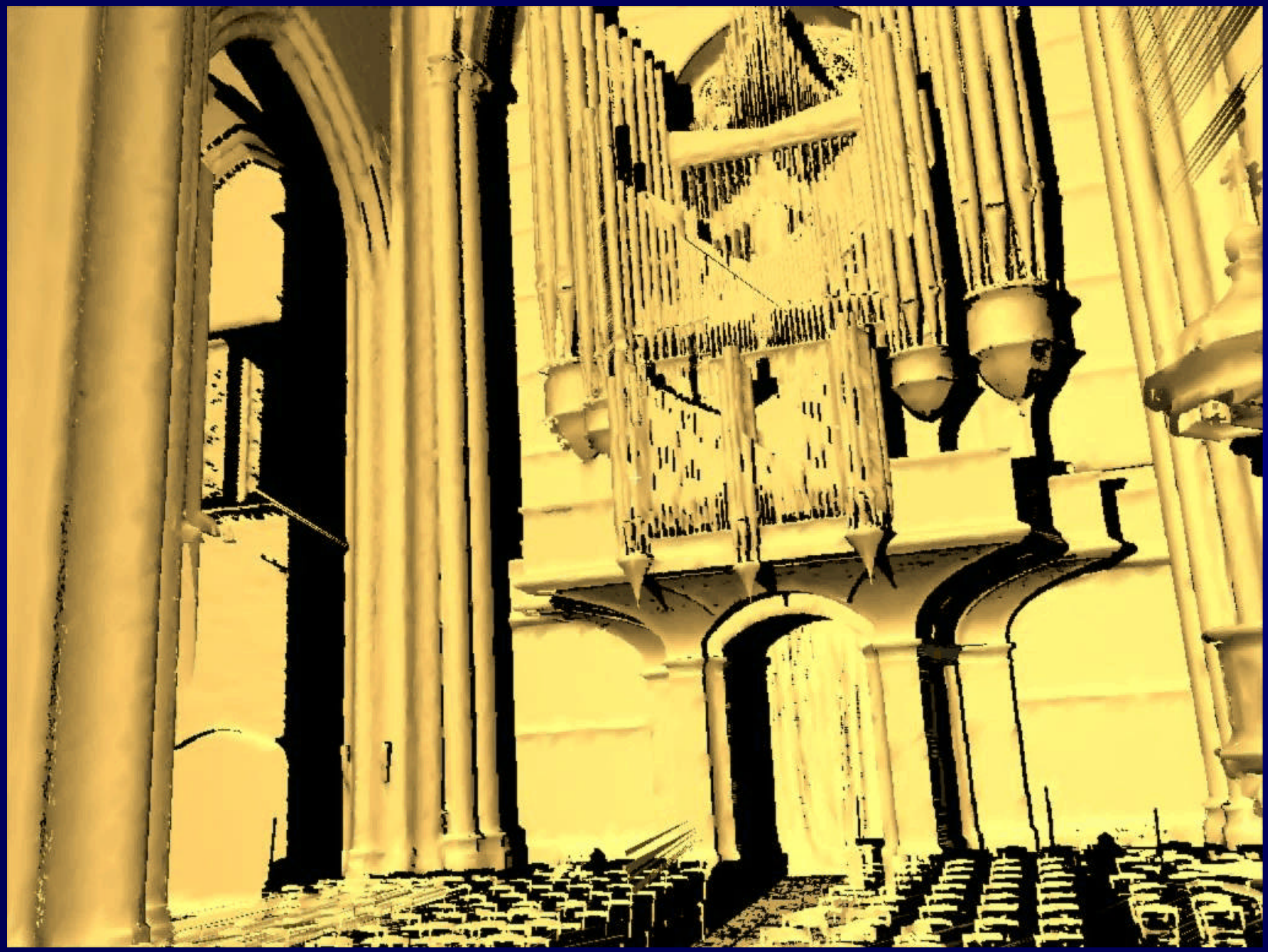
Registered Scans – Beauvais Cathedral



Beauvais Cathedral Model: Exterior Fly Over

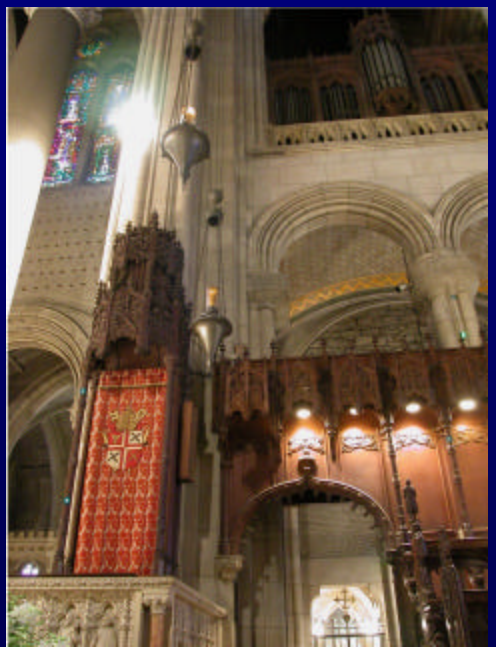


Beauvais Cathedral Model: Interior Fly-Thru

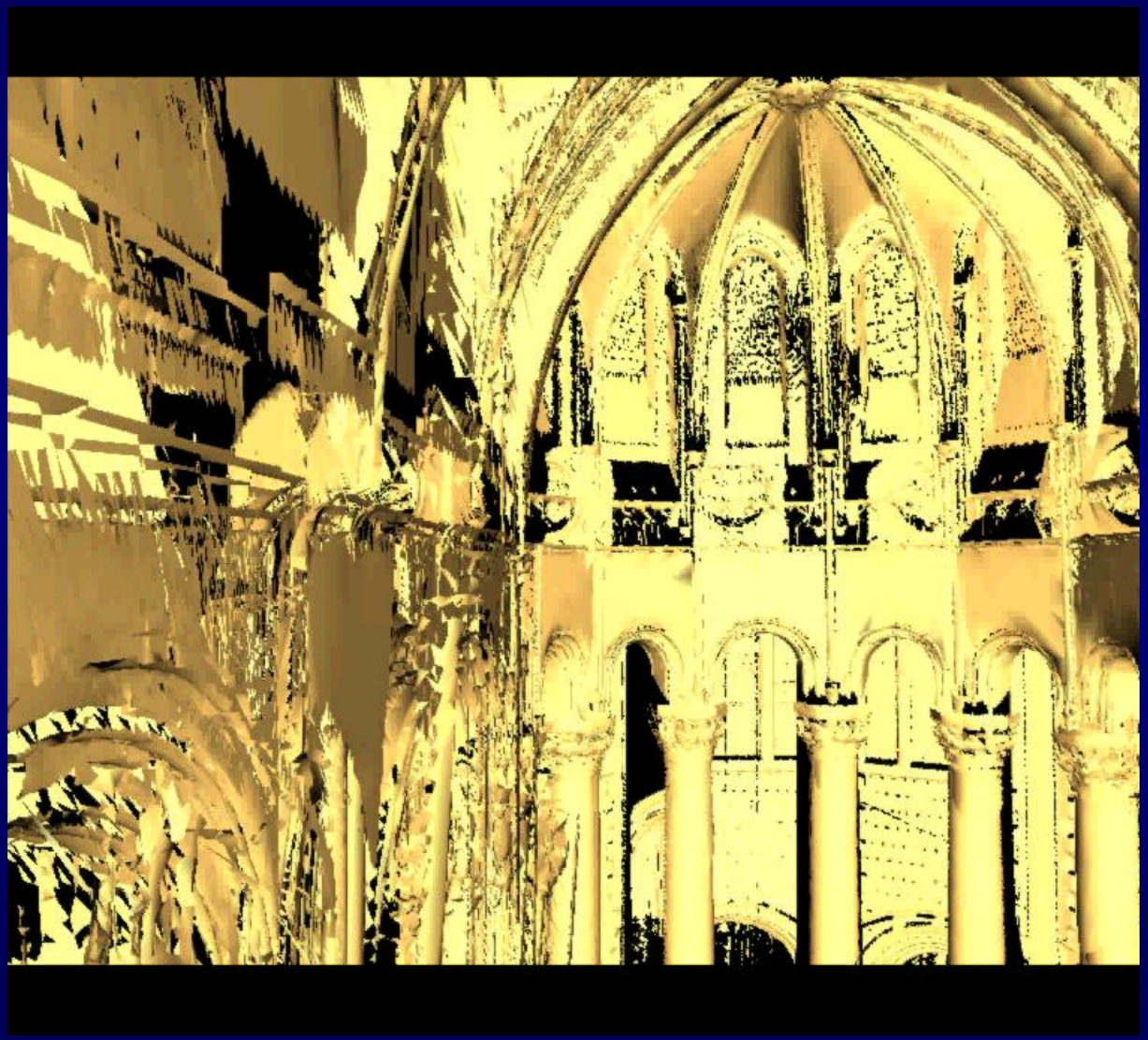


Cathedral of St. John the Divine, NYC

Cathedral of St. John: Interior Spaces

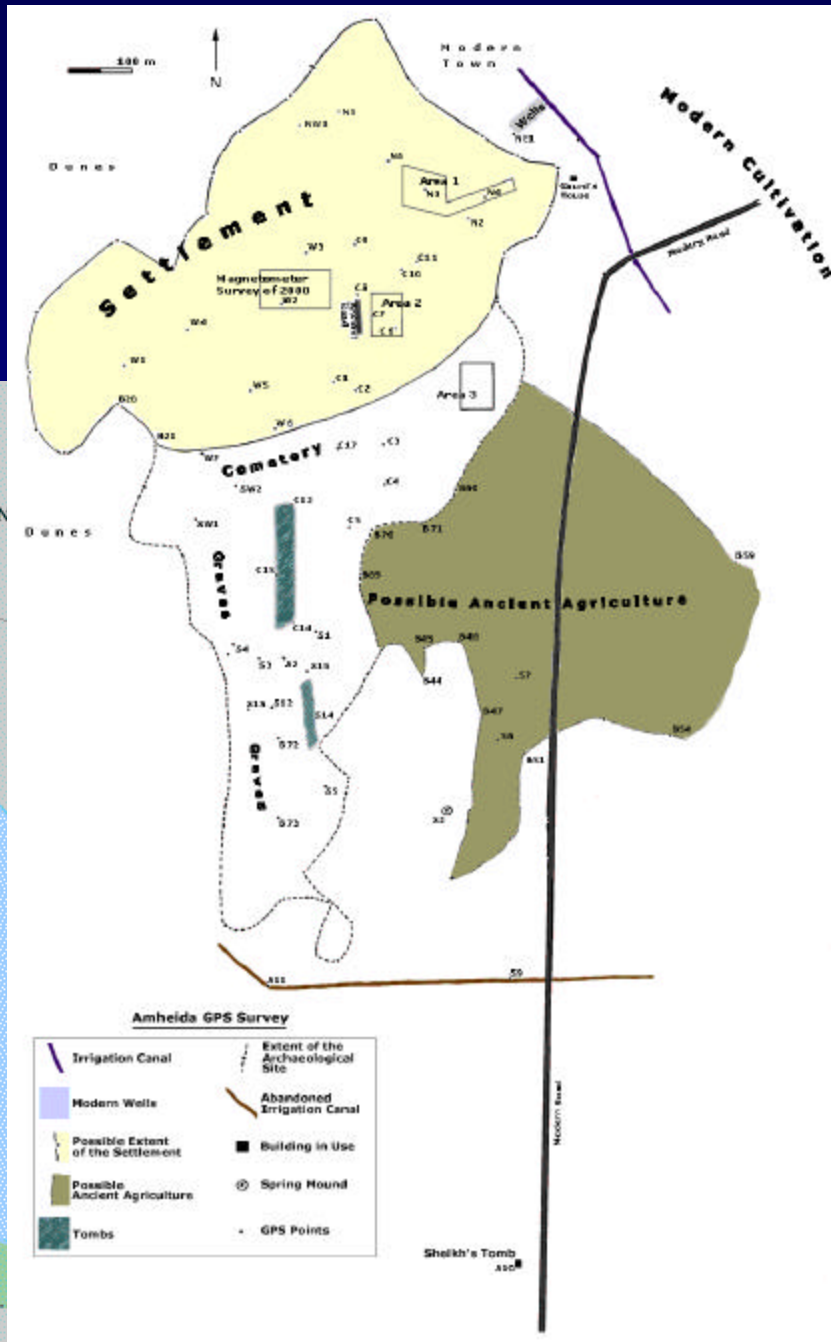


Cathedral of St. John The Divine: Interior Scans

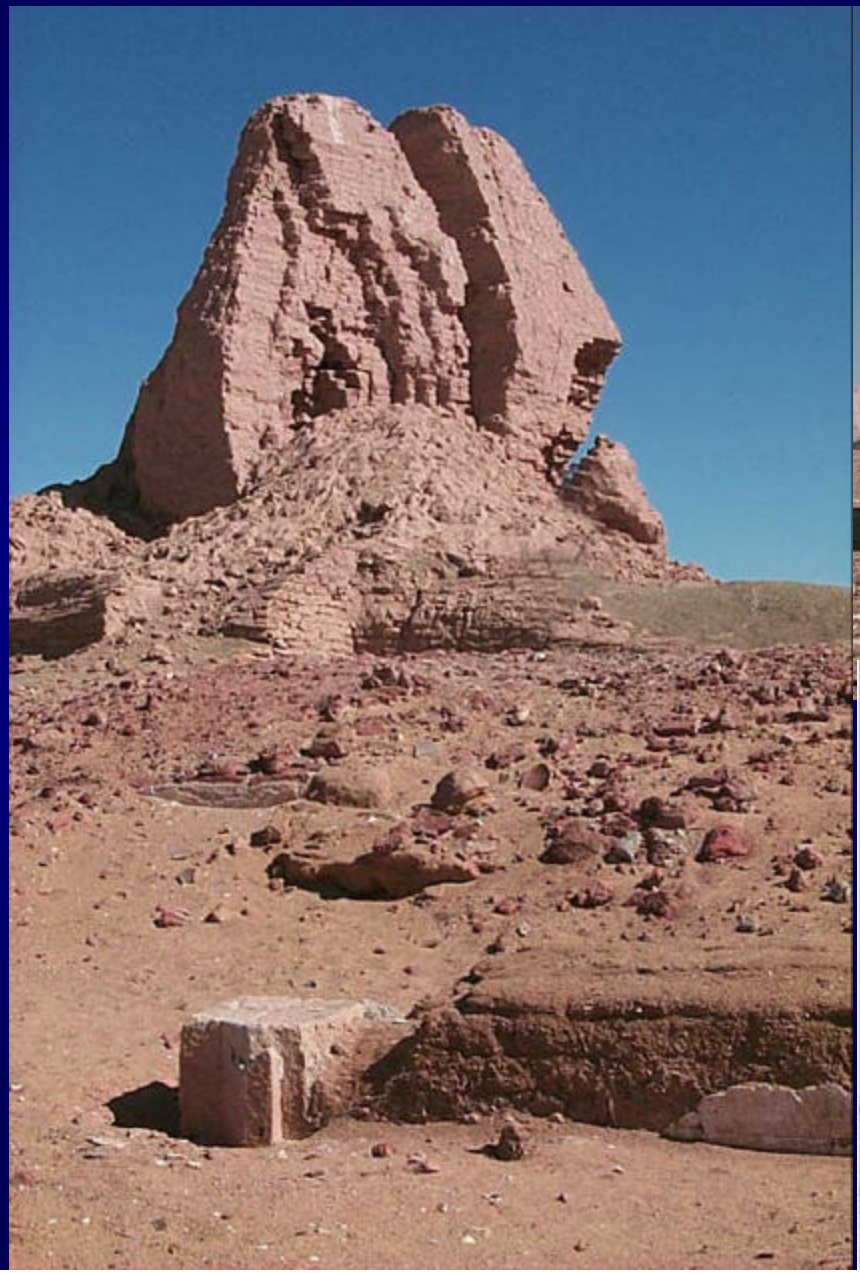


Amheida, Egypt Site

- Large Site in Western Desert
- Ancient Roman City of Trimithis
- Pharaonic, Ptolemaic, Roman ruins



Structures at Amheida



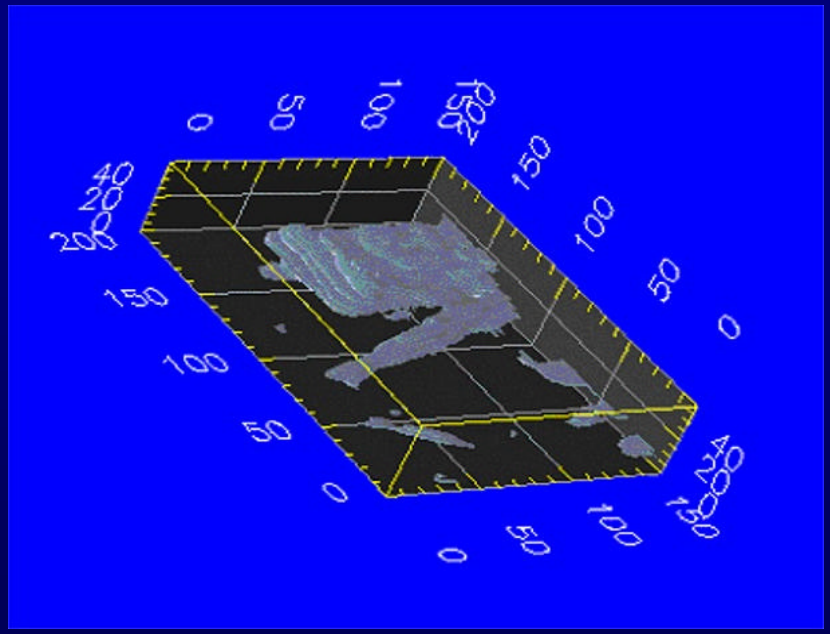
Kharga Area

Dakleh Oasis

Winter 2002: Underground Sensing

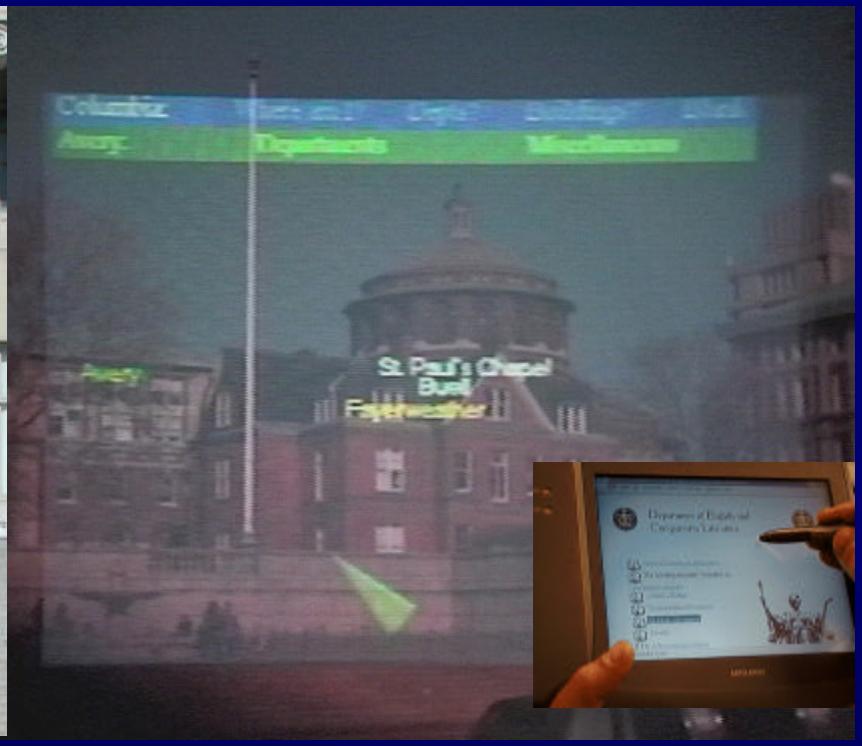
Underground Sensing, Versteeg et al

Seneca Village, Central Park NY



Pipes and Plates Uncovered by GPR

Software Technology for Augmented Reality Systems



Develop mobile augmented reality systems

- software infrastructure
- user interface

Assist mobile users in exploring unfamiliar environments

What's Next?

- Team returns to Amheida in January
- Mobile above-ground scanning, Underground mapping, Augmented reality system for archaeologists
- Database begins to be populated from site
- Web access to artifacts, images, models etc.
- Complete structural model of Beauvais Cathedral
- Scan exterior of St. John's
- Automatic registration methods for 3-D models refined
- Automatic texture mapping of 3-D models extended to arbitrary environments